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# PERSONALITY ASPECTS OF PILOT-ERROR ACCIDENT INVOLVEMENT


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ABSTRACT

The consistently high frequency of pilot error accidents in both military and civilian aviation programs does much to support exploratory research which might help alleviate the problem. Cattell's Sixteen Personality Factor Questionnaire (16 PF) and a dynamic decision making task (under risk) were given to 51 Army aviators. Accident files were then examined in order to classify the aviators as to their prior pilot error accident involvement. Stepwise discriminant analyses revealed that the decision making task scores were unrelated to the pilot error accident groupings while the 16PF scores were able to correctly classify 86% of the aviators as to whether or not they had been previously listed as a cause factor in a military aviation accident.

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TABLE OF CONTENTS

LIST OF TABLES

## INTRODUCTION

Pilot-error accidents* have plagued military aviation programs since they evolved into large scale operations.[1] The human element in complex aviation man-machine systems has consistently been a disproportionate contributor to aviation accidents. Thorndike reported in a review of Air Force accidents occurring in 1949 that 62.4% of the accidents were listed as having the pilot as the major cause factor and 24.0% involved errors of other personnel, while only 26.2% involved materiel failure.[1]

Twenty-five years have passed and military aviation programs have changed markedly, yet human error or pilot-error accidents continue to dominate accident statistics. The United States Army Agency for Aviation Safety (USAAAVS) recently reviewed the aircraft accidents which occurred between 1958 and 1972.[2] The results of their study indicate that pilot error was a factor in 80% of the accidents occurring during that fifteen year period. A striking sum of 58 million dollars per year was attributed to pilot error in terms of injuries, fatalities and aircraft damage.

A recent study of civilian air carrier accidents investigated by the National Transportation Safety Board (NTSB) during the period 1964-1969 indicated that pilot-error accidents are not unique to the military environment. The safety board found that in 58% of the fatal accidents the pilot factor was listed as one of the cause factors.[14] An accident report by the Lovelace Foundation separated human error studies into three basic categories: (1) impact studies, (2) case histories, and (3) aircraft subsystems failures.[3] While many of these types of studies are essential,[2,4,5] they concern only post hoc examination of factors involved in aviation accidents. Post hoc evaluations of cause factors such as equipment design and transient environment elements which interact with the human element provide valuable information which can be entered back into training, selection and design loops, thus rectifying identified problems.

However, a total examination of the pilot error problem would not be complete without examining the personality of pilots involved in pilot-error accidents. If one were able to identify common characteristics or personality factors associated with pilot-error accident involved personnel then these factors could be examined and remedial actions could be taken. Corkindale noted that a research void existed in this area of accident prediction.[6] He pointed out, in his technical evaluation of the proceedings of the conference on the "Behavioral Aspects of Aircraft Accidents", that certain topics such as prediction

* Accidents in which the pilot is considered to be a definite or suspected cause factor.

of accident liability for an individual were not receiving sufficient research attention.

Corkindale's point was well made but the concept of accident liability brings one into what was once a highly controversial area.[7,8] The concept of accident proneness in industrial, surface transport, and aviation settings has been addressed in several research projects. The original thesis concerned the supposition that some individuals possessed traits or idiosyncrasies predisposing them to relatively high accident rates (i.e., were accident prone). If one accepts the concept of accident proneness as defined above, the next step is to expose these critical distinguishing factors which should correlate with and predict accident involvement. However, the personal characteristics identified in the early studies were not consistent between studies and accident areas identified. Thus, the inconclusive and inconsistent data correctly damaged the stable traits theory of accident proneness. However, several methodological problems plagued the early studies of the accident prone investigation era; there was no determination of accident responsibility; exposure was not controlled; and personality measures were of unknown reliability and validity.[7] Thus, Haddon, Suchman and Klein concluded "...studies indicate that accident proneness is a psychological abstraction based upon a statistical frequency. As often happens when a statistical distribution is given theoretical significance, the concept quickly assumed much more meaning than was originally intended. The unacceptability of the concept of accident proneness in a technical sense should not, however, be taken to mean that personal factors do not play an important role in accidents. In fact, rejecting the concept of accident proneness, with its implication of a global personality trait forces one to search for many different psychological factors and their significance in given environmental circumstances"[7] (p. 444).

Thus, personal factors in accidents cannot be ignored, especially in light of the high rate of pilot-error accidents occurring in the military and civilian communities. Perhaps accident investigation and classification programs have advanced sufficiently to correctly identify pilot errors and sufficiently separate them from accidents which were solely caused by materiel, environment and other nonpilot factors. The purpose of the current project is not to inflame the accident prone controversy, but to use valid and reliable personality tests and a decision making task (under risk) and examine their relationship to pilot-error accident involvement. Several articles have suggested the use of decision making tasks to possibly clarify the accident involvement issue[3,9,10] and Ricketson, et al., have identified faulty decision making and unnecessary risk taking as elements frequently occurring in pilot-error accidents.[2] Therefore, if decision making task scores and personality scores can relate to pilot-error accident involvement, the potential evolves for a reduction in pilot-error rate resulting from vocational counseling, selection and training adjustments or whatever procedures deemed appropriate. Pilot error is by far the largest problem area in Army aviation safety and is therefore most in need of behavioral research.[2] Even a

small percentage reduction in the pilot-error rate could result in lives saved, injuries reduced and a large reduction in direct and indirect accident costs.

## METHOD

### Subjects

Participating personnel for this study were 51 volunteer Army aviators (Warrant and Commissioned Officers) assigned to various duty positions at Fort Rucker, Alabama. The subjects were tested without our prior knowledge as to their previous accident involvement. The mean age of the subjects was 29.1, with ages varying from 23 to 42. The rank of the participants ranged from Chief Warrant Officer-2 to Lieutenant Colonel.

### Apparatus

The Sixteen Personality Factor Questionnaire (16 PF) form A was administered to each subject.[11] The 16 PF questionnaire is a multidimensional set of sixteen primary factors and four secondary factors designed to make available, in practical testing time, information about a person's standing on the majority of the primary and secondary personality factors. The 16 PF is useful in the aviation setting because it was designed specifically to measure personality factors found in the normal populations. The second personality measure used was the Mehrabian Achievement Scale which provides an indication of one's need for achievement or need to attain success.[12]

Determination of prior pilot-error accident involvement was made through an investigation of USAAAVS accident records. Each aviator had to be listed as a cause factor in at least one aviation accident (either major, minor or incident) in order to be classified as pilot-error accident involved.

The decision making apparatus consisted of a stimulus display panel and a response panel similar to that used by DeKock.[13] Centered at the top of the stimulus display panel was a red bulb which could be activated by the subject. Below the red bulb was a clear bulb which was energized at the beginning of the decision making portion of each trial. Two standard sixty second timers with hundreds of a second hands were located on either side of the two bulbs. The timer on the left recorded the Total Time of the trial. The timer on the right recorded Your Time, which was the time at the beginning and the end of each trial in addition to the time recorded after the subject engaged the Start button. A CT-202 BRS counter was located below the clear stimulus light. This device contained two independent tenths of a second digital counters. These timers presented the Your Time and the Total Time values in a more easily read digital display.

The response panel was located at the bottom of the apparatus and contained a red Start button on the right and a black Stop button on the left. The decision making apparatus was located in a small quiet room with the controlling equipment, BRS logic units and tape drive, placed in an adjacent room.

## Procedure

Upon arrival, the subjects were given a brief description of the project and completed a background information form. The subjects were then given the instructions for the decision making task.

The decision making task, like the DeKock task, attempted to abstractly create a dynamic decision making situation. Each trial of the task began with both timers (Your and Total Time) being activated. Both timers stayed on from 9 to 13 seconds (this interval varied on each trial) until the clear light was energized, stopping the Your Time timers. The clear light was energized at varying brightness levels according to the length of time it was to stay on. If the clear light was to stay on for eight seconds, it was energized at a higher brightness level than if it was to remain on for twelve seconds. The clear light increased in brightness throughout the interval and always went out at the same fixed intensity.

When the clear light came on, a decision had to be made by the subject: (1) he could push the Start button and reactivate his Your Time timers, or (2) he could decide to not reactivate the Your Time timers and lose the time that the clear light was on. The clear light time interval varied on each trial from eight to twelve seconds. Thus, if the subject decided not to reactivate the Your Time timers he would lose from eight to twelve seconds, depending on the trial. This passive decision could have been considered desirable, since no penalty could be incurred by this choice.

The original decision or active choice in which the subject reactivated the Your Time timers always placed the subject in risk of a time penalty. A subsequent decision by the subject and the clear light interval on each trial determined whether or not he would receive: (1) no time penalty, (2) an eight second penalty, or (3) a sixteen second penalty. The subject's basic decision then was to determine whether or not his red light, which was energized when he reactivated the Your Time timers after the clear light was energized, would go off automatically before the clear light went out. The red light was energized for ten seconds on each trial while, again, the critical clear light time intervals ranged from eight to twelve seconds. Thus, if the subject reactivated the Your Time timers and the red light immediately after the clear light came on, the subject would receive no penalty on 40% of the trials. On the other 60% of the active response trials, the subject had to push the Stop button

before the clear light went out (this action produced an eight second penalty) or receive the largest penalty (sixteen seconds) if the red light was still on when the clear light went out.

In review, the clear light was activated for ten seconds on each trial. The subject could start the timers and the red light immediately after the clear light came on and the red light would go out automatically before the clear light went out on two of the five practice trials and four of the ten trials in each test block. This sequence of decisions was the riskiest option but it could also produce the least time loss along with no time penalty occurring.

On the other active response trials in which the subject pushed the <u>Start</u> button in response to the onset of the clear light, the subject had to push the <u>Stop</u> button (incurring an eight second penalty) while the clear light was still activated in order to avoid the sixteen second penalty. Of course, the passive option was always available at the start of each trial, the subject could decide to not reactivate the timers and lose only the time the clear light was on, thereby incurring no penalties but also precluding the possibility of not losing any time on that trial.

The entire decision making task lasted approximately forty-five minutes. The subjects were given (1) four instructional trials illustrating all possible options the subject might choose, (2) a five trial practice period; and (3) three blocks of ten trials with the subject's timers reset after each block or period.

<u>Dependent Variables</u>

The dependent measures obtained from the task were the following times totaled over the last block--Total Time, Your Time, Obstruction Time (the time after the clear light came on and before the subject pushed the <u>Start</u> button) and Obstruction Time plus Penalty Time score. Scores were also obtained on the frequency of the five possible decisions: (1) start and correctly deciding to leave on (SC)--no penalty; (2) start and incorrectly deciding to leave on (SIC)--16 second penalty; (3) start and stop correctly (SSC)--8 second penalty; (4) start and stop incorrectly (SSI)--8 second penalty, but could have received no penalty if no stop had been made; (5) no start (NS)--no penalty but the time the white light was on, was lost.

Averages of these scores over the three blocks of trials were also obtained. Measures obtained from the 16 PF questionnaire (both primary and secondary scores) and the need achievement test were also used as predictor variables.

## RESULTS

Since there were multiple predictor variables (personality variable scores and decision making scores) involved in the study, stepwise discriminant analyses for two groups were used. The two groups were the pilot-error accident involved (PEAI) group and the pilot-error accident free (PEAF) group, as determined by the USAAAVS accident reports. The first stepwise discriminant analysis involved the use of the sixteen primary and four secondary factors obtained from the Sixteen PF along with one N-Ach score from the Mehrabian N-Ach scale. The analysis indicated that three of the twenty-one factors could significantly discriminate between the two groups of aviators. These three factors and their F and probability values are listed in Table I. A Wilks Lambda value of 0.52 was found when the three factors listed in Table I were combined linearly to separate the accident involved (PEAI) subjects from the accident free (PEAF) subjects.

TABLE I

Stepwise Discriminate Function: Separation of the PEAI and PEAF Groups (N=51) using the 16PF Test Scores and the N-Ach Score

| Step No. | Personality Variable Entered | F Value | *p* |
|---|---|---|---|
| 1 | Group Dependent vs. Self-Sufficient ($Q_2$) | 16.52 | .01 |
| 2 | Practical vs. Imaginative (M) | 14.36 | .01 |
| 3 | Forthright vs. Shrewd (N) | 4.89 | .05* |

* The remaining variables showed a separation of the groups at a probability level of greater than .05.

Table II provides descriptive data on the personality test factors for the two groups.

TABLE II

Means and Standard Deviations for the Pilot Error Accident Involved (PEAI) and Pilot Error Accident Free (PEAF) Groups on the 16 PF Variables and the Mehrabian Need Achievement Scale.

| Personality Variable Name | PEAI Mean | PEAI S.D. | PEAF Mean | PEAF S.D. | Combined Group Mean |
|---|---|---|---|---|---|
| Reserved vs. Outgoing (A)[a,b] | 4.21 | 1.92 | 4.51 | 2.02 | 4.43 |
| Less vs. More Intelligent (B) | 6.85 | 1.35 | 7.40 | 1.49 | 7.25 |
| Affected by Feelings vs. Stable (C) | 6.28 | 1.54 | 5.94 | 1.89 | 6.03 |
| Humble vs. Assertive (E) | 6.14 | 2.34 | 7.16 | 1.74 | 6.88 |
| Sober vs. Happy-Go-Lucky (F) | 6.21 | 2.08 | 5.81 | 1.83 | 5.92 |
| Expedient vs. Conscientious (G) | 6.07 | 1.49 | 6.32 | 1.76 | 6.25 |
| Shy vs. Venturesome (H) | 5.50 | 2.62 | 5.83 | 1.96 | 5.74 |
| Tough vs. Tender-Minded (I) | 4.35 | 2.16 | 4.24 | 1.63 | 4.27 |
| Trusting vs. Suspicious (L) | 5.42 | 2.34 | 5.37 | 2.09 | 5.39 |
| Practical vs. Imaginative (M) | 4.71 | 1.68 | 6.32 | 1.43 | 5.88 |
| Forthright vs. Shrewd (N) | 5.14 | 1.46 | 4.70 | 1.41 | 4.82 |
| Self-Assured vs. Apprehensive (O) | 4.64 | 1.44 | 4.21 | 1.61 | 4.33 |
| Conservative vs. Experimental ($Q_1$) | 5.21 | 2.04 | 6.00 | 2.00 | 5.78 |
| Group Dependent vs. Self-Sufficient ($Q_2$) | 5.07 | 1.14 | 6.83 | 1.46 | 6.35 |
| Undisciplined vs. Controlled ($Q_3$) | 6.42 | 1.50 | 5.72 | 1.66 | 5.92 |
| Relaxed vs. Tense ($Q_4$) | 5.07 | 2.01 | 5.43 | 1.70 | 5.33 |
| Introversion vs. Extroversion ($Q_I$) | 6.14 | 2.01 | 6.14 | 1.75 | 6.14 |
| Adjustment vs. Anxiety ($Q_{II}$) | 4.95 | 1.48 | 5.07 | 1.47 | 5.03 |
| Sensitivity vs. Tough Poise ($Q_{III}$) | 7.07 | 1.88 | 7.55 | 1.85 | 7.42 |
| Dependence vs. Independence ($Q_{IV}$) | 5.67 | 1.70 | 7.14 | 1.35 | 6.74 |
| Low vs. High Need Achievement | -1.71 | 24.18 | 5.62 | 18.33 | 3.60 |

[a] The letter designation of each personality factor follows the descriptive variable name.

[b] Lower scores are associated with the left side of the continuum and vice-versa; average range includes sten scores five-six on the 16 PF factors.

Table III shows the number of cases classified into their respective groups. With the prior probability of membership in a group being placed at .50-.50, the personality scores were able to correctly classify 44 of the 51 aviators.

TABLE III

Number of Cases Classified (N=51) into Accident Groups using 16 PF Test Scores and the N-Ach Score

| | INVOLVED | FREE |
|---|---|---|
| Group | | |
| Involved | 11 | 3 |
| Free | 4 | 33 |

The scores obtained from the decision making task were not effective in discriminating between the PEAI and PEAF groups. None of the decision making scores reached an F level for inclusion of 2.50 or greater so the stepwise discriminant analysis was halted.

It was found that the subjects were approximately equal in age (29.5-PEAI to 29.7-PEAF) and rank yet showed a divergence on the critical factor of total flight hours. The PEAI group averaged approximately 1506.35 total flight hours at the time of their mishaps while the PEAF group averaged approximately 1948.25 total flight hours at the time of the testing for this project. The accidents were fairly evenly divided between the UH-1 (8), a utility helicopter and OH-13/OH-6 (6), reconnaissance helicopters. Two accidents occurred in a Cobra (AH-1G) and one each in a training helicopter (TH-55) and a fixed wing observation aircraft (O-1A).

The pilot-error accident data appears to conform very closely to the Poisson distribution which has often been examined in relation to the distribution of accidents within a group of interest.[1] Table IV illustrates the theoretical Poisson distribution for the average number of accidents (0.27) found in the current sample along with the actual values for this sample.

TABLE IV

COMPARISON OF ACTUAL AND THEORETICAL ACCIDENT DISTRIBUTIONS

| Accident Frequency | Actual Number of Cases | Theoretical Number of Cases |
|---|---|---|
| 0 | 37.0 | 37.7 |
| 1 | 11.0 | 11.2 |
| 2 | 2.0 | 1.5 |
| 3 | 1.0 | 0.15 |
| 4 | 0.0 | 0.01 |

The Poisson distribution has typically been used to attempt to determine if variables other than chance contribute to the frequency distribution of accidents for a given sample.

## DISCUSSION

The results of the study indicate that three of the factors on the 16 PF (Group Dependent or Self-Sufficient, Practical vs. Imaginative, and Forthright vs. Shrewd) were able to discriminate between those individuals who had been identified as causal factors in aviation accidents and those individuals who had not been listed as a causal factor in aviation accidents. Perhaps the most interesting aspect of the results of the stepwise discriminant analysis was that the three personality measures were able to correctly classify 86% of the aviators tested as to their prior pilot-error accident involvement. An examination of the factors on which the two groups showed a significant separation reveals that the accident free aviators were generally more self-sufficient, imaginative, and forthright These individuals scored high on $Q_2$, which would describe them as being resolute, self-sufficient, resourceful, and accustomed to making their own decisions alone. On the lower end of the $Q_2$ continuum, individuals have been described as being group dependent, relying more on social approval, and more conventional or fashionable. The accident involved aviators fell in the mean range on this scale significantly lower than the accident free aviators.

The second most discriminating factor was the practical vs. imaginative (M) variable. The accident free pilots scored high on the M scale, an outcome which perhaps would not be expected. High M individuals have been described as being imaginative, Bohemian, absent-minded and unconventional. Persons scoring lower on M have been described as practical, have "down-to-earth" concerns, are conventional, and concerned with immediate interests and issues. The accident involved aviators, as before, scored in the mean range or just below it on the M scale (see Table I).

The third factor was the forthright vs. shrewd scale (N) on which the accident free pilots scored just below the mean range. Persons scoring lower on the N scale have been described as unpretentious, spontaneous, natural, and content with what comes. Higher scores on the N scale indicate a person who is astute, worldly, polished, socially aware, smart, and "cuts corners." The accident involved group's N score fell in the mean range, yet was high relative to the accident free group's score.

The decision making task scores were not predictive in the current project. Scores on the decision making task were unable to discriminate between the two groups of pilots, perhaps because decision making errors were not always listed as the causes which classified the accidents as pilot error. Thus faulty decision making behavior in prior aviation accidents was not associated with all the pilots classified as pilot-error accident involved. It is also possible that the task was too complex. However, decisional aspects of pilot performance should not be ignored in future pilot-error investigations. Decision making behavior has been consistently identified as a contributing factor in pilot-error accidents.[2,3] Capturing the critical elements which are related to decision making behavior exhibited in flight and then reproducing them in the laboratory setting will be a challenge for future projects.

Examination of the current accident data in accordance with the Poisson distribution reveals that the frequency of accidents resembles that which would be expected by chance or nonsystematically related factors. However, by considering only data which does not conform to the Poisson distribution are we, as Thorndike suggested,[1] making an error in potentially disregarding a real phenomenon. The magnitude of the pilot-error accident problem dictates that we explore every feasible research avenue in order to relieve that problem. A type II error (a false assumption that a phenomenon exists) at this point in accident research would be far less severe than a type I error (a false assumption that a phenomenon does not exist).

Another problem in the interpretation of accident data is the inability to equate individuals' exposure to high risk situations. If total number of flight hours was used alone as an indicant of risk exposure, the accident free individuals in the current project would appear to be biased toward higher pilot-error involvement than the accident involved aviators. Thorndike stated that one could obtain a measure of one's risk exposure

by multiplying flight hours by the type of aircraft flown.[1] The development of an exposure index would be of value for safety agencies but such factors as type of mission or flight assignment and intensity of the flight environment should be included before the index could be considered complete.

Since nine groups of errors have now been identified within the pilot-error accident framework,[2] perhaps future investigations will be able to correlate specific error groups with specific personality traits. For example, overconfidence, violation of flight discipline and excessive motivation to succeed (three currently identified pilot error variables) might be statistically associated with a group of individuals possessing a specific set of personality traits. One then might infer that future aviators possessing like traits might have a higher probability of committing the three associated errors. The next step then would be to assign these individuals to a position where these specific traits might be desirable. If one could not optimize the utilization of these traits through placement or assignment, then vocational counseling and/or selection changes could be considered. Specific variables involved in pilot-error accidents were examined in the current project but incomplete accident forms prevented an appropriate investigation.

A cross-validation study will follow the present report in order to examine the consistency of the personality factors identified. Further research will also examine environmental and situational variables which interact with the human element in the aviation setting to produce human errors.

In conclusion, the personality variables used in this study were very predictive in the identification of those aviators who had been involved in pilot-error accidents. It appears that a combination of two factors: (1) the use of a reliable personality scale measuring "normal" personality traits, and (2) the more uniform classification of cause factors in aviation accidents by USAAAVS personnel, provided the capability for the prediction of pilot-error accident involvement through personality variables. To reiterate, an accident proneness position was not assumed in the current project. However, hopefully an approach was initiated which might provide probability statements about an aviator's potential for pilot-error accident involvement.

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13. ABSTRACT

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